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FUEL MANAGEMENT OPPORTUNITIES ON THE LOLO NATIONAL FOREST: AN ECONOMIC ANALYSIS

Donald B. Wood[1]

ABSTRACT

Examines economic feasibility of managing nonslash fuels in mature timber to reduce the costs and damages of wildfire. A 1.2-million-acre (496 000 hectare) study area is stratified by timber value, fire occurrence rate, and fuel hazard. Maximum potential fuel management benefits--based on the elimination of expected class E+ fires--are estimated for each stratum and compared to treatment cost estimates. Concludes that fuel treatment to protect timber alone is not economically feasible, but may be justified if treatment enhances other forest values such as wildlife habitat, livestock forage, etc.

KEYWORDS: forest fuels, fire management, hazard reduction, fuel management

Reducing fire hazard by treating fuels is frequently proposed as a means of reducing the acreage burned by wildfire. Although fuel management could certainly curtail wildfire, whether and under what conditions benefits will exceed costs is essentially unknown. Consequently, the extent to which fuel management can be depended upon to solve present and future fire problems is uncertain. This report assesses whether fuel treatment is an economically feasible fire management tool. Results should contribute toward decisions involving the implementation of fuel management programs.

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[1] Dr. Donald B. Wood is an Assistant Professor of Forestry at Northern Arizona University, Flagstaff. He received his B.S. in Finance from the University of Utah in 1967, and an M.F. and Ph.D. in Forest Economics from Utah State University in 1973 and 1978, respectively. Dr. Wood joined the school of Forestry at Northern Arizona University in 1976.

The study was conducted on the Lolo National Forest in Montana and was limited to analyzing the treatment of nonslash fuels in mature timber. The overall objective was to estimate the acreage of mature timber stands that could reasonably be expected to yield fuel management benefits greater than or equal to treatment costs. Benefits considered were averted damages to timber and other forest commodities and reductions in suppression and rehabilitation costs.

Timber, suppression, and rehabilitation benefits were estimated using methods derived in a previous study (Wood 1978). (Methods are described in the following section.) Treatment impacts on nontimber commodities such as recreation and wildlife were considered indirectly. The value of nontimber outputs required to meet any portion of treatment costs not covered by timber, suppression, and rehabilitation benefits was determined and judged to be either reasonable or unreasonable. Treatment costs are based on estimates extracted from the literature.

Estimating Benefits

Benefit estimates are based on the assumption that fuel management will result in maximum response--defined as the elimination of fires greater than 300 acres (121.5 hectares) (Class E+ fires). In the Northern Region, these large fires account for more than 80 percent of the acres burned and most of the fire damage. Because the location and timing of future Class E+ fires are unknown, the approach is based on probabilities, and benefits are expressed in averages or expected values.

Fifteen years of Northern Region fire records were used as a basis for estimating expected Class E+ acres burned. Examination of these records revealed that the proportion of fires reaching Class E+ size was directly related to the spread rate component of "fuel type at point of origin." During the period examined, the percentages of fires escaping to Class E+ size according to this variable were: low, 0.203 percent; medium, 0.428 percent; high, 0.774 percent; and extreme, 5.739 percent. The percentages provide the basis for estimating acres saved annually. The fuel type of the analyzed stand determines the appropriate percentage which (in decimal form) is multiplied by the average number of fires expected annually. The result, expected annual Class E+ fires, is multiplied by mean Class E+ fire size (2,022 acres, 818.9 hectares) giving expected annual Class E+ acres burned--and an estimate of annual acres saved.

Total acres saved is derived by multiplying annual acres saved by the number of fire seasons encompassed by treatment and harvest. It is assumed that the first fire season immediately follows treatment and the stand is harvested after the fire season of the scheduled harvest year. As a result, the number of fire seasons is one greater than the number of full years between treatment and harvest. For computational purposes, if a stand is to be harvested in T years, one benefit increment is assumed to occur at the beginning of the first year and one at the end of each of the ensuing T years.

Benefits due to increased harvest receipts are determined by multiplying total acres saved by estimated stumpage value per acre and discounting the result to present value. The present value of any timber that would have been salvaged is deducted to give net timber benefits.

Burned timber is assumed salvaged in the year it burns. Because the discounting period and volume per acre change each year, present values are independently computed year by year and then added to yield total salvage value. This step is deleted if burned timber is not salvaged.

Finally, suppression and rehabilitation cost savings are estimated. Annual savings are determined by multiplying annual acres saved by per acre costs derived from historic cost data ($230 per Class E+ acre burned). The annual costs are then discounted to present value.

The present value of fuel management benefits is dependent on the length of time between treatment and harvest (T). As time between treatment and harvest increases, benefits initially increase but typically peak and decline as a result of discounting. The value of an acre saved declines by a factor of $(1 + i)^{-1}$ (i = interest rate) each year T is extended. After some point, the reduction in per acre value will exceed the positive impact of saving additional acres from burning and total benefits will decline. As additional years are added, this divergence will increase and the decline in present value will accelerate. At current 7 to 10 percent interest rates, benefits typically peak within 15 years of harvest.

The procedures discussed are summarized in the equation:

$$F = (T + 1)\ bh(1 + i)^{-T} - \sum_{t} bs_t(1 + i)^{-t} + \sum_{t} bc(1 + i)^{-t}$$

Where: F = present value of fuel management benefits;

T = total years between treatment and harvest;

t = years elapsed since treatment;

b = annual expected Class E+ acres saved;

h = per acre harvest value;

s_t = per acre salvage value in year t;

c = per acre suppression and rehabilitation costs.

The first term represents the value of additional live timber harvested; the second, salvage value foregone; and the third, suppression and rehabilitation cost savings. In the ensuing discussion, fuel management benefits have been converted to "benefits per acre protected" by dividing stand benefits by their respective acreages.

METHODS

Study Area

An area of 1.2 million acres (486 000 hectares), approximately two-thirds of the Lolo National Forest, was selected for the study. The remaining one-third (Ninemile and Superior Ranger Districts) was eliminated due to data deficiencies. Evaluating all mature stands within the study area would have been arduous and costly. Instead, only stands representative of the highest treatment benefits available were selected. Previous experience had shown that the highest benefits resulted from mature stands having high and extreme fuel types and fire occurrence rates greater than 0.5 annual ignitions per 10,000 acres (4 050 hectares).

Because young and unstocked stands were not considered, the study may not encompass all economically feasible fuel management opportunities. Benefits for such stands are typically low due to long discounting periods. In some cases, however, the risk of fire spreading to adjacent mature stands may significantly increase treatment benefits.

Data Collection

The data used to provide physical stand variables were available in various forms. Other information, however, had to be estimated:

1. Harvest dates were known only for stands scheduled for harvest within 5 years.

2. Future stumpage values were unknown.

3. The extent of salvageable burned timber was unknown.

Estimates were based on maximizing fuel management benefits.

Resultant assumptions are as follows:

1. Stands will be harvested in the number of years required to maximize fuel management benefits.

2. Stumpage prices are assumed to be $180 per thousand board feet. This is almost $27 higher than the maximum average stumpage price on the Northern Region for any species within the last 10 years (Western White Pine: 1977 price $153.14 per M bd. ft.).

3. Only timber burned in the year of harvest will be salvaged.

With this approach, the estimated benefits indicate the maximum fuel management expenditure that can be justified without considering nontimber values.

Fuel maps showing rate of spread and resistance to control were available for the study area. Fuel types having high and extreme spread rates were traced on overlays.

Fire occurrences were plotted for the period beginning in 1950. Boundaries were drawn around areas having relatively homogeneous occurrence rates. Subdivisions with similar rates were then combined to form five occurrence zones and an average rate for each zone was calculated. The five zones were:

Zone	Annual fires per 10,000 acres
1	0.735
2	0.901
3	1.180
4	2.683
5	3.646

Having identified areas meeting the minimum criteria for hazard and occurrence rate, individually, areas fulfilling both requirements were identified by combining fuel type and occurrence rate maps and marking the overlap on map overlays.

The third step was to outline areas meeting the first two criteria that contained mature timber stands, with the aid of Forest Service aerial photograph interpretation (P.I.) maps. Although P.I. maps indicate whether stands are mature, they do not provide information on timber species, age, or volume. Instead, stands were classified by habitat type, then volumes were determined from yield tables for habitat types on the Lolo National Forest. Because stand ages were unknown, the average yield for mature stands of all ages was computed for each habitat type. The per acre volumes for the four types recorded were: 5.762 M bd. ft., 8.351 M bd. ft., 9.604 M bd. ft., and 11.406 M bd. ft. Multiplying by $180 yielded per acre values--$1,037, $1,503, $1,729, and $2,053, respectively--that were subsequently used to determine fuel treatment benefits.

Stands having similar fuel hazards, occurrence rates, and timber values were combined and per acre benefits were computed for each resulting stand category. The reader should recognize that benefits for stands within a category could vary somewhat from computed values because of differences in surrounding areas. A Class E+ fire in any one of the stands would probably spread to surrounding areas and the benefit of preventing the fire would depend partially on the values of adjacent stands. Stands surrounded by higher value areas will yield greater benefits than those surrounded by less valuable areas. Results computed for a category must therefore be interpreted as falling within a range of benefits exhibited by stands within that category.

RESULTS AND DISCUSSION

Of the 1.2 million acres (486 000 hectares) examined, 25,655 acres (10 390 hectares) (2.14 percent) met criteria for evaluation (high- or extreme-hazard fuel type, occurrence rate greater than 0.5 fires per 10,000 acres (4 050 hectares), and mature timber). The distribution of acreage by value per acre and occurrence zone is shown in table 1 (all acres had a high hazard fuel type). More than 75 percent of the qualified acreage was in the lowest occurrence zone.

Table 1.--*Distribution of evaluated acreage by value per acre and zone*

Zone	Timber value per acre				
	$1,037	$1,503	$1,729	$2,053	Total
	Acres				
1	2,432	843	13,541	1,661	18,477
2	624	513	2,439	1,526	5,102
3	187	125	1,518	107	1,937
4	--	--	--	--	--
5	--	138	--	--	138
Total	3,243	1,619	17,498	3,294	25,654

Benefits per acre-protected for all occurrence-rate/timber-value combinations are given in table 2. Using a 7 percent interest rate, values range from $11.95 to $80.48 per acre; with a 10 percent interest rate, values ranged from $8.77 to $58.87. Average per acre benefits were $17.66 (7 percent) and $12.92 (10 percent).

Table 2.--*Fuel management benefits per acre protected for 7 and 10 percent interest rates*

Occurrence zone	Interest rate	Timber value per acre			
		$1,037	$1,503	$1,729	$2,053
	Percent	*Dollars*			
1	7	11.95	14.81	16.22	18.26
	10	8.77	10.85	11.87	13.33
2	7	14.64	18.16	19.89	22.38
	10	10.74	13.30	14.55	16.34
3	7	19.18	23.78	26.05	29.31
	10	14.07	17.42	19.05	21.40
4	7	--	--	--	--
	10	--	--	--	--
5	7	--	80.48	--	--
	10	--	58.87	--	--

Although fuel treatment costs in uncut stands have not been determined for the Northern Rockies, regional slash treatment costs provide a reasonable estimate. In 1972, the average cost for treating slash by broadcast burning in the Northern Region was $21.54 per acre ($30.83 per acre in 1977 dollars) (Northern Region, USDA Forest Service, 1974). Cooper (1975) estimates that prescribed burning costs in uncut stands in the West range from $1 to $50 per acre, occasionally reaching $100. Thirty dollars an acre, then, is not an unreasonable estimate, considering the risks and difficulties of treating standing timber.

A portion of the study area can be treated with fuelbreaks or fuel mosaics. Wood (1978) estimated that fuelbreaks on 10 percent of an area would cost a minimum of $31 per acre protected. Mosaics could cost less per acre protected, depending on treatment intensity and proportion of area treated. To account for this possible reduction in area treated, cost-per-acre-protected was arbitrarily reduced by one-third to $20 per treatment. If the initial treatment is followed by one additional maintenance treatment after 10 years, the present value of costs becomes approximately $30 for the 7 percent interest rate and $28 for the 10 percent rate. To simplify the following discussion, $30 will be used in both cases to evaluate the relative magnitude of benefits.

Only 138 acres (55.9 hectares) or about one-half of 1 percent of the qualified area produced benefits exceeding $30 for both the 7 and 10 percent cases. For benefits to exceed treatment costs in more than half of the evaluated area, treatment costs would have to be less than $10 per acre protected, again assuming one additional $10 treatment after 10 years. Remember that one-half of the evaluated area is only about 1 percent of the total study area.

Two major factors contribute to the relatively low benefits. First, fire occurrence rates in the evaluated area were, on the average, low. In the one high-occurrence-rate area, benefits were substantial. Second, timber yields are low, even on the best sites. Values per acre are also low even when assuming generous stumpage prices and zero salvage.

Nontimber Benefits

Because nontimber values must be considered in justifying fuel treatment, potential contributions toward the \$30 per acre treatment cost were examined. Calculations assume that an acre saved from burning will produce a constant amount of nontimber value annually until the stand is harvested. This does not imply, however, that total annual nontimber benefits accruing to fuel treatment will be constant--cumulative acres saved increases each year. For example, if an average of 1 acre per year is expected to burn in a 1,000-acre stand, 1 acre would be the first-year benefit. This same acre would continue to produce benefits the following year in addition to a second acre saved, doubling the first year benefits. Thus, annual nontimber benefits are an increasing function of years elapsed since treatment. The present value-per-acre-protected can be expressed:

$$V_o = 1/r\ [ab + 2ab(1 + i)^{-1} + 3ab(1 + i)^{-2} + \ldots + (T + 1)\ ab(1 + i)^{-T}]$$

Where: V_o = present value of nontimber outputs per acre protected

r = number of acres protected

a = annual value output of an acre saved from burning

b = annual expected Class E+ acres saved

T = total years between treatment and harvest

i = interest rate

The equation assumes that once an acre is burned, nontimber outputs are lost for the entire period of analysis. By solving the above equation for "a," we can determine the annual output per acre necessary to yield a given or desired level of benefits. The annual nontimber value required to bring benefits to \$30 per acre (assuming the same timber values and time periods) was thus determined for the study area. Results of this determination are presented in table 3. Table 4 shows the values required for benefits of \$30 per acre protected on the same area where no timber is harvested (suppression and rehabilitation cost savings are still included).

Table 3.--*Annual nontimber benefits required (in addition to timber benefits) to yield benefits of \$30 per acre protected*

Occurrence zone	Interest rate	Timber value per acre			
		\$1,037	\$1,503	\$1,729	\$2,053
	Percent	*Dollars*			
1	7	184.00	165.32	161.01	137.12
	10	286.47	272.30	273.03	251.04
2	7	127.73	105.12	96.37	72.63
	10	212.01	193.71	189.80	167.81
3	7	68.70	42.17	28.75	5.02
	10	133.89	111.42	102.71	80.67

Table 4.--*Annual per acre, nontimber benefits required to yield benefits of $30 per acre protected when timber value is zero*

Occurrence zone	Interest rate	Period of benefit accumulation	
		20 years	30 years
	Percent	*Dollars*	
1	7	232.46	155.11
	10	326.54	245.64
2	7	189.63	126.54
	10	266.38	200.38
3	7	144.80	96.62
	10	203.40	153.00
5	7	46.86	31.27
	10	65.82	49.52

The tabulated figures are based on the following assumptions: (1) burned acres do not regain the capacity to produce nontimber benefits until the scheduled harvest date, or for 20 or 30 years if timber is not harvested and (2) fuel management will be totally effective in eliminating Class E+ fires. If either assumption is discounted, annual output value would have to be increased to cover treatment costs.

To what extent can nontimber values on the Lolo National Forest defray protection costs? Clawson (1976) estimates that the average annual gross value (including timber) produced by the National Forest System is $6.63 per acre. Most of the nontimber benefits required are several hundred percent higher (tables 2, 3). The difference would be even more pronounced if management costs were deducted. This does not mean that these values are unattainable, but unless Clawson's figures are grossly low, values of this magnitude would be unusual and would occur only in areas of high recreational use and development, outstanding esthetic quality, endangered species habitat, and similar areas. The implication for the Lolo National Forest is that nontimber resources are unlikely to materially increase the acreage that can be economically treated.

Forest values must be high because the acreage saved is small relative to the number of acres treated or protected. For example, treating a 1,000-acre stand with a high-fuel hazard and an occurrence rate of one fire per 10,000 acres per year would result in an average of about 1.5 acres saved per year. If treatment benefits extend 20 years, an average of 30 acres would be saved. The present value of the benefits produced by the 30 acres must be divided by 1,000 to determine benefits per acre protected.

The treatment itself may do more to increase wildland values than the reduction of fire danger. For example, treating fuels by prescribed fire could result in increased forage production. In the above example, only 30 acres produced benefits as a result of Class E+ wildfire elimination; as a result of increased forage production, all 1,000 acres might produce benefits.

CONCLUSIONS

Timber saved, and savings in costs of fire suppression, and costs of rehabilitation, would rarely exceed costs of fuel treatment on the Lolo National Forest. This conclusion holds even under the most optimistic comparisons of costs and benefits.

Protecting nontimber values will not improve the economic feasibility of fuel management. Considering the low probability of fire, nontimber values would have to be very high to significantly defray treatment costs.

Fuel management may be feasible in areas holding unusually high timber values or nontimber values (or both), or where treatment costs are much lower than hypothesized here. Fuel management may also be feasible when it enhances--not merely protects--nontimber values such as wildlife habitat, livestock forage, recreation, and so on.

Conclusions of this study may not apply to other forests in the Northern Rockies nor forests in other regions. The conclusions hold true for most of the Northern Rockies where mature timber stands generally produce low yields. Fuel treatment may be feasible in parts of the Pacific Northwest where old-growth stands attain high volumes and values. Fuel hazards and rates of fire occurrence would have to be at least as severe as those found on the study area.

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